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Effects of hot-working parameters on microstructural evolution of high nitrogen austenitic stainless steel

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ABSTRACT

The microstructural evolution of high nitrogen austenitic stainless steel under various deformation conditions was characterized by isothermal compression test. Special attention was paid to the variation of microhardness and its relationship with grain size was also derived. Results indicated that two kinds of strengthening mechanism acted during the whole temperature range. When the temperature is between 950 °C and 1150 °C, grain refinement plays a dominant role. But at temperatures lower than 900 °C, no recrystallization occurs and substructure (dislocations and twins) contributes massively to the strength. Furthermore, it was found that the peak precipitation of grain boundary carbides which are seriously detrimental to toughness appeared at 850 °C. Therefore, an optimizing processing route could be recommended to achieve a good combination of high strength and good toughness. Firstly, the hot-rolling at 950–1100 °C should have large stain to gain refined grains, and accelerated cooling is applied from 950 to 750 °C in order to avoid carbide precipitation along grain boundary. Lastly, at temperatures lower than 750 °C warm-rolling with medium stain can get substructure strengthening effects.

1. Introduction

High nitrogen austenitic stainless steel (HNASS) has obtained great attentions due to its favorable combination of mechanical, chemical and physical properties: high strength and toughness, nickel-saving, good corrosion resistance and non-magnetic susceptibility, which enable its use in extensive fields [1–5]. Grain refinement is a kind of widely applied method to obtain both high strength and good ductility. Therefore refining the grain size as small as possible is important for the high nitrogen austenitic stainless steel. It is well known that the grain size of ferritic steels can be easily refined by the γ/α phase transformation. However the high nitrogen austenitic stainless steel is absent of γ/α phase transformation, so the only method to refine the grains is recrystallization during hot deformation [6]. Investigation reveals that the nitrogen is in favor of grain refining, so great grain refinement hardening can be achieved for this steel [7,8].

The previous researches [1,7] find that the thermo-mechanical control process (TMCP) is an effective method to control the microstructure and optimize the mechanical properties, which brings grain refinement and substructural hardening to the austenitic stainless steels. Moreover, the study [7] reveals that the presence of carbides in the steel affects the mechanical properties, especially the carbides along the grain boundary. Therefore an ideally designed TMCP should minimize the precipitates that are detrimental to corrosion resistance and toughness, and keep a good balance between strength and ductility. The result of Kim et al. [9] shows that the secondary phases as nitrides show strong strain rate dependence. And Kaputkina et al. [10] reveals that appropriate Mo addition can inhibit the precipitation and growth of nitrides and carbides, and widens the permissible range of hot deformation temperatures.

Though the investigations on the HNASS are extensive, however the study of the effect of hot-working parameters on the HNASS is limited. So in the present paper, microstructural evolution and variation of microhardness during hot deformation of a low nickel high nitrogen steel (HNS) with a base composition of 21Cr–16Mn (wt.%) are investigated. The precipitation behavior of the carbides is also studied. All these information will help choose appropriate processing parameters for obtaining desired microstructure and properties.

2. Materials and experimental procedure

The material used in this study is a nitrogen-alloyed austenitic stainless steel manufactured by Taiyuan Iron and Steel Co. Ltd., and the manufacturing route is: 40 t Electric Arc Furnace (EAF) → 40 t

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